prevent oxidation and distilling of tar from the coal. Changes to equipment also were necessary, so that the dried coal would contain a minimum of coarse and extremely fine material and yet meet all other requirements as to quality.

These process limitations have required considerable testing and changing of the coal-preparation unit during the spring and summer of 1949. The unit is now ready for operation and is capable of preparing 5 to 8 tons of specification pulverized coal per hour.

During the early spring of 1949, approximately 70,000 gallons of coal tar pasting oil and 10,000 gallons of solid-free, light, aromatic, flushing oil were obtained for the purpose of breaking-in the heavy-oil storage and pasting equipment and for initiating the liquid-phase coal operations. Intensive operator training and break-in runs of the flash distillation-area equipment, heavy oil-blending equipment, paste making, and centrifuges are now in progress.

Gas-Synthesis Plant

For the gas-synthesis process, coal must first be converted to a hydrogen-carbon monoxide gas mixture and this, in turn, converted to liquid products. Transforming coal into gas can be approached in several ways. At Louisiana, Mo., a method is being tried that reacts powdered coal with steam and oxygen. Two processes are contemplated for making finished synthetic fuel products from the synthesis gas.

As shown in the block diagram (fig. 45), the plant is composed of five parts, namely, oxygen production, gasifier, purification, Fischer-Tropsch-synthesis, and refinery.

The oxygen plant, a Linde-Frankl unit brought from Germany, produces 1 ton per hour of oxygen of 98 percent purity.

The coal-handling facilities are intended to dry run-of-mine coal and reduce it to approximately 200-mesh, after which it is conveyed pneumatically and stored in bulk hoppers, wherefrom it is fed to the gasifier system.

The gasifier uses coal, oxygen, and steam superheated to 2,500° F. It will make up to 90,000 cubic feet an hour of synthesis gas. The reaction vessel is a refractory-lined steel shell 6-1/2 feet in inside diameter by 9 feet inside length. Design rates are 2,300 pounds of coal, 2,000 pounds of oxygen, and 2,900 pounds of superheated steam per hour.

After leaving the gasifier, the gas is cooled in a waste-heat boiler, water-scrubbed, and then put through an electrical precipitator for the removal of dust. Sulfur compounds in the gas are removed by a series of treatments at pressures of 300 to 450 pounds per square inch. The allowable dust and sulfur compounds are in the magnitude of tenths of grains for 100 cubic feet of gas.

In the synthesis section of the plants, this gas is treated catalytically to form it into synthetic-fuel raw products. In the demonstrated process, the cooling oil will carry away the generated heat from the fixed catalyst bed of the reactor. Following this, the liquid products will be refined into specification-grade gasoline, Diesel oil, and waxes. Facilities will be available for distilling the gross liquid product into its component commercial fractions and for converting the heavy gases to

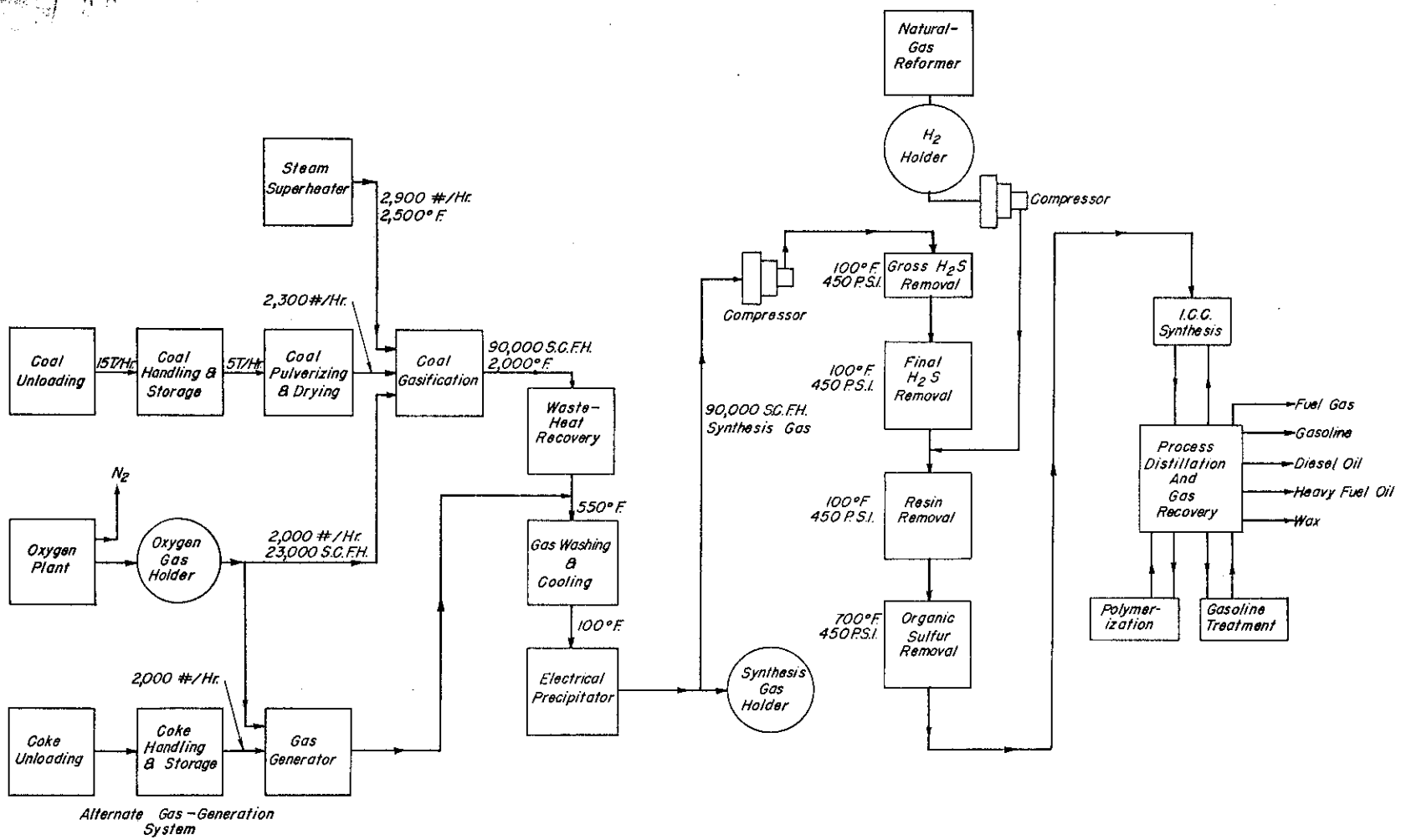

Figure 45. - Block diagram of flow, Gas Synthesis Demonstration Plant.

additional gasoline. Intermediate products will be upgraded by catalytic treatment or by addition or blending in order to make high-quality final products.

The over-all plant is designed to make 50 to 80 barrels a day of total finished products. To produce 80 barrels per day, 140,000 cubic feet per hour of synthesis gas is necessary. 90,000 will be produced in the Koppers gasifier, the remaining 50,000 cubic feet per hour will be made in one of the former Missouri Ordnance Works natural gas-steam cracking units and will be blended with the products of the coal gasifier.

This plant was designed and constructed by the Koppers Co., Inc., of Pittsburgh, Pa. Engineering work was estimated to be 83 percent complete on June 15, 1949, and construction was 41 percent complete on May 31.

The various parts of the plant are being built successively, which permits break-in runs to be made in some parts while other sections are still in the design or construction stage.

The oxygen plant has been under intermittent operation since December 20, 1948. It has been demonstrated that the plant will produce its design capacity of 1 ton of 98-percent-purity oxygen per hour. At present it runs continuously and supplies oxygen as required for the gasifier.

The gasifier plant was substantially completed in May 1949, and several trial runs have been made to date. This process had never before operated on this scale, and it was necessary to set up an experimental program in addition to the normal testing procedure. The plant has been operated at full capacity, and early trials have indicated that it will operate according to the principle upon which it was designed, and that it is possible to make a gas that has the general composition desired. Further trials are in progress. A typical gas composition from one of the trial runs shows:

	Percent
CO	38
H_2	42
CO_2	16
N_2	3
Miscellaneous	1

Engineering Studies and Cost Estimates

Directing and supervising the design and construction of the two demonstration plants and their preparation for initial operations was a continuous major engineering task. Numerous investigations had to be carried out for this purpose, and many other studies were initiated at the request of other Government agencies and technical institutions. Some of this work was completed and published.

Detailed study of the microfilms by the Technical Oil Mission to Europe continued. A classified card index of all available reels was prepared and soon will be arranged in manuscript form. Thirty additional translations were made and issued as "T" reports.100/

100/ For copies of translations of T.O.M. reels write to Bureau of Mines, Louisiana, Mo.

Information regarding commercial-size synthetic-fuel plants was supplied to the Department of the Army, Corps of Engineers, to assist them in their survey to find suitable commercial plant site areas.

In a paper,101/ the thermal efficiency of an ideal coal-hydrogenation plant was discussed in detail, and the efficiency obtainable was compared with that of a typical German hydrogenation plant. A number of new ideas and processes are discussed and incorporated into the process flow to improve the over-all heat efficiency from 28.9 percent for a typical German plant to a figure of approximately 55 percent.

Later, coal-hydrogenation improvements incorporated in a preliminary plant design102/ indicated a calculated thermal efficiency of 48 percent. Major proposed improvements over the German processes include the gasification of coal under pressure for hydrogen production and delayed coking of residue for greater oil recovery.

A report of investigations on the subject of estimated cost of producing heavy fuel oil by hydrogenation of coal was prepared.103/ The report contains process information and cost figures that indicate that fuel oil can be produced from coal at a cost of approximately $4 per barrel in a 10,000-barrel-per-day plant using a coal costing $3 per ton at the mine.

Economic studies are always of extreme importance when the feasibility of a new process or operation is considered. A report has been written104/ to help those who desire to use a method of making uniform cost estimates for the following purposes:

1. To make an economic study of the operations of plants and equipment of new design.
2. To make economic studies of new products and methods of producing them.
3. To include all elements of operating cost, such as direct, indirect, fixed costs, etc.
4. To present the various cost elements so arranged that they may be compared with other cost estimates of like or similar nature.

101/ Skinner, L. C., Dressler, R. G., Chaffee, C. C., Miller, S. G., and Hirst, L. L., Thermal Efficiency of Coal Hydrogenation: Ind. Eng. Chem., vol. 41, 1949, p. 87-95.

102/ Hirst, L. L., Skinner, L. C., and Donath, E. E.: Improvements in Hydrogenation of Coal: Bureau of Mines Inf. Circ. 7486, 1948, 7 pp.

103/ Hirst, L. L., Skinner, L. C., Clarke, E. A., Dougherty, R. W., and Levene, H. D., Estimated Cost of Producing Heavy Fuel Oil by Hydrogenation of Coal: Bureau of Mines Rept. of Investigations 4413, 1948, 53 pp.

104/ Van Noy, C. W., Dunville, T. C., Dressler, R. G., and Chaffee, C. C.: Guide for Making Cost Estimates for Chemical-Type Operations: Bureau of Mines Rept. of Investigations 4534, 1949, 64 pp.

The Bureau of Mines' synthetic-fuels program was discussed in a general way, and the demonstration plants were described in some detail to the American Gas Association.105/

Technical Reports and Foreign Document Work

Synthetic Liquid Fuels Abstracts

The current literature has been covered and abstracted thoroughly; German patent references in the foreign-document files have been searched, and those of interest have been abstracted. Over a thousand abstracts have been made and published, and about 1,000 copies of each issue of the abstracts have been distributed. Indexes of all abstracts issued since October 1944 have been made, thus opening for easy inspection all of the synthetic-fuels literature issued since that date.

Bibliographies

A review and compilation of the literature on the pressure hydrogenation of liquid and solid carbonaceous materials is in progress.

The Fischer-Tropsch bibliography is still in the formative stage, the card index is being completed, and the closing date for the manuscript will be moved ahead as far as possible so that the current literature references and the German patent abstracts from the foreign documents can be added. It is anticipated that this bibliography will contain about 5,000 abstracts in its completed form.

Foreign Documents

Work has been continued throughout the past year in collecting, arranging, classifying, and indexing the foreign documents from German sources containing information of interest on synthetic liquid fuels. Individual subject indexes of the 279 TOM reels have been prepared, and these are now being consolidated into a single index. Enlargement prints selected from the TOM reels and printed CIOS, BIOS, and FIAT reports, as well as translations of documents from various sources, are available. Documents other than TOM reels are being indexed in considerable detail, and an attempt will be made to correlate this index with the TOM reel index. The document index now covers more than 1,500 separate documents of specific interest to synthetic liquid fuels and composes 10 standard file drawers of index cards. Seven complete sets of these cards have been prepared by means of ditto reproduction and placed in advantageous places for reference. It is anticipated that when this index is completed, reference will be made to every document or report from German sources that contain specific information of interest in connection with synthetic liquid fuels.

105/ Hirst, L. L., Markovits, J. A., Dressler, R. G., and Batchelder, H. R., The Bureau of Mines Demonstration Plants in the Synthetic Fuels Picture: Proc. Am. Gas Assoc., 1948, pp. 317-325.